Comparison of Predicted and Observed Plume Trends at Fuel and Solvent Contaminated Sites

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Performance of Natural Attenuation

- **Recommendations for remediation of contaminants in groundwater are frequently based on modeling natural attenuation processes to predict contaminant trends and plume dynamics.**
- **An extended time frame for remediation is often the basis for implementation of more expensive engineered remedial alternatives.**

Problem Statement

Discrepancies between observed and predicted contaminant plume behavior suggest that values of critical model input parameters are inaccurate. Therefore, natural attenuation processes are not always accurately simulated, potentially leading to less cost effective remedial actions .

Plume Comparison Objectives

Compare contaminant monitoring data to model predictions in order to assess the accuracy of selected fundamental model input parameters and assumptions, with the goal of making recommendations to improve the accuracy of natural attenuation model predictions.

Study Scope

- **Evaluate trends in contaminant concentrations and plume dynamics for 12 sites contaminated with fuels and/or solvents.**
- **Summarize biodegradation and source reduction rates used for previous model predictions.**
- **Compare predicted versus observed contaminant concentrations and plume extent.**
- **Evaluate the accuracy of biodegradation and source reduction rates used in models.**

Natural Attenuation Initiative Locations

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Fuel Hydrocarbon Sites

- **Seven sites, primarily modeled using BIOPLUME II numerical code or BIOSCREEN analytical code.**
- **Instantaneous reaction used for aerobic oxidation.**
- **Anaerobic degradation rates using Buscheck and Alcantar (1995) or Conservative Tracer (AFCEE, 1995) methods.**
- **Source reduction rates based on an assumed percentage per year (geometric), or estimated using the Hydrocarbon Spill Screening Model (USEPA, 1994).**

Fuel Hydrocarbon Sites

Site	Contaminant	Model
Travis AFB Gas Stations, CA	BTEX	BIOPLUME II
Myrtle Beach AFB POL Yard, SC	BTEX	BIOPLUME II
Hill AFB Site 870, UT	BTEX	BIOPLUME II
Elmendorf AFB Site ST-41, AK	BTEX	BIOPLUME II
King Salmon Airport Site SS-12, AK	BTEX	BIOPLUME II
Langely AFB Site SS-04, VA	Benzene	BIOSCREEN
Dover AFB Site SS27/XYZ, DE	BTEX	BIOPLUME II

"Successful" Models

Site	Source Reduction Rate (%/yr)	Anaerobic Decay Rate (day^{-1})	Reaeration Rate (day^{-1})
Elmendorf ST41(D)	8	0.005	0.002
Myrtle Beach POL (MB2)	12 - 27	0.002	--
King Salmon SS-12	10	IR	0.001
Hill Site 870	0**	IR	0.003

"Overly Conservative" Models

Site	Source Reduction Rate (%/yr)	Anaerobic Decay Rate (day^{-1})	Reaeration Rate (day^{-1})
Elmendorf ST41(A)	0	0.005	0.002
Myrtle Beach POL (MB1)	1.0	0.002	--
Travis Gas Stations	2.3 - 4.9	0.0005	--
Langley SS-04	3.5	IR	--
Dover SS27/XYZ	0, 12, 17	IR	0.003

Fuel Hydrocarbon Site Recommendations

- **Use range of "realistic" source reduction rates (e.g., 8 %/yr to 23 %/yr for BTEX).**
- **Use of source reduction rates less than 5 %/yr should be justified based on site-specific data.**
- **If appropriate, collect LNAPL samples over time to derive a site-specific weathering rate.**
- **First-order decay rates for BTEX less than 0.001 day^{-1} should be used with caution. In absence of site-specific data, higher rates may be more accurate .**

Air Force Natural Attenuation Studies

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Chlorinated Solvent Sites

- **Five sites, primarily TCE modeled using MODFLOW/MT3D numerical code.**
- **First-order degradation rates calculated using methods of Buscheck and Alcantar (1995) and Moutoux *et al*. (1996).**
- **Source generally modeled using “Black Box” approach.**
- **Source reduction rates based on an assumed percentage per year (geometric).**

Chlorinated Solvent Sites

F.E. Warren AFB Site LF-03, WY	TCE	MODFLOW/MT3D
Hill AFB OU5, UT	TCE	MODFLOW/MT3D
Tinker AFB Site FTA-2, OK	TCE	MODFLOW/MT3D
Cape Canaveral Site FT-17, FL	TCE , VC	MODFLOW/MT3D
Columbus AFB Site LF-06, MS	Total Chlorinated Ethenes	van Genuchten and Alves (1982)

"Successful" Models

Site	Source Reduction Rate (%/yr)	First-Order Decay Rate (day^{-1})	Half-Life (years)
Tinker Site FTA-2	2	3E-4 to 3E-5	5.6 to 63
Cape Canaveral Site FT-17	6 - 10	9E-4	2.1

"Overly Conservative" Models

Site	Source Reduction Rate (%/yr)	First-Order Decay Rate (day^{-1})	Half-Life (years)
F.E. Warren Site LF-03	7.3	7.6E-5	25
Hill OU5	3	6E-6	317
Columbus Site LF-06	Constant	3.5E-3	0.54

Chlorinated Solvent Recommendations

- **The use of decay rates calculated using the method of Buscheck and Alcantar (1995) are appropriate as a first approximation, even if plume stability cannot be verified.**
- **The use of the Moutoux *et al*. (1996) method should be limited to strictly anaerobic flow paths, and to situations where conservation of chlorinated ethene mass is indicated.**

Chlorinated Solvent Recommendations

- **Natural weathering rates for chlorinated ethenes (TCE) are not well documented, but use of a range of 6 to 10 percent per year (geometric) is a suitable first approximation.**
- **The ability of natural attenuation processes to stabilize chlorinated solvent plumes is not as generally accepted as for fuel hydrocarbon sites.**

Special Considerations:

As more information regarding the evolution and attenuation of fuel hydrocarbon and chlorinated solvent plumes is obtained over time, the level of confidence associated with key fate and transport model input parameters such as decay rates and source weathering rates will increase.

Special Considerations (concluded):

The necessity for using significantly conservative modeling assumptions due to a lack of information regarding realistic values for these parameters will diminish. Continued monitoring of fuel hydrocarbon and chlorinated solvent sites may provide an empirical basis for more frequent application of MNA as opposed to engineered remediation.